FIELDIANA · GEOLOGY

Published by

CHICAGO NATURAL HISTORY MUSEUM

Volume 10 | August 26, 1949 | No. 8

SOME LOWER HURONIAN STROMATOLITES OF NORTHERN MICHIGAN

Eugene S. Richardson, Jr.

Curator of Fossil Invertebrates

The Randville dolomite, outcropping in a few exposures north of Felch, Dickinson County, Michigan, contains an abundance of stromatolites that provide an additional record of Pre-Cambrian life and are of value in the study of the local geologic structure. A small collection was made in the field in the fall of 1947, but many specimens more suitable for biological study were left behind, because it was not possible to free them from massive ledges with the tools at hand. Future field work should yield valuable material.

I am grateful to Professor F. J. Pettijohn, of the University of Chicago, for having told me of the occurrence of these stromatolites, and to Mr. and Mrs. Lorin Clark, my hosts and guides in the field. Mr. Clark very clearly explained the stratigraphic and geologic background of the occurrences. Dr. Francis Drouet, Curator of Cryptogamic Botany of Chicago Natural History Museum, gave me unstintingly of his time in many valuable discussions of modern blue-green algae.

Laminated, variously shaped structures in limestones of all ages since the earliest Algonkian are given the non-committal name of "stromatolites," a term introduced by Kalkowsky (1908, p. 68) as preferable to "calcareous algae." Stromatolites are almost certainly deposits formed on the thalli of primitive plants, but it is difficult to determine the particular type of plant on which the deposits occurred. Blue-green algae (Myxophyceae),[1] green algae (Chlorophyceae), and many other simple plants, including mosses, of the present-day flora, deposit lime crusts where lime is available to them. It has generally been accepted, however, that the blue-green algae have been responsible for those crusts preserved as stromatolites. Schwellnus and Le Roex (1945) adopted this explanation after eliminating other hypotheses. Howe (1932) came to the same

[1] Cyanophyceae or Schizophyceae, of authors.

conclusion, citing the resemblance between the gross form of stromatolites and that of modern myxophycean colonies. Walcott (1914), Moore (1918), Gruner (1923), and Maslov (1938) interpreted certain microscopic structures as algal cells or as evidence of such cells. The "fruit conceptacles" in *Cryptozoon proliferum* Hall (Wieland, 1914) remain an anomalous bit of evidence, as modern Myxophyceae, to which group Wieland assigned the species, have no such structures.

Since the individual blue-green alga is typically a tiny uniserial chain or filament of cells, usually from one to twenty-five microns in width (a few attaining a width of over a hundred microns), it is obvious that any macroscopic structure formed by such plants must be the product of a colony or colonies. Recent myxophycean colonies are formed by combination of the mucilaginous or gelatinous sheaths surrounding the individual filaments. Fine clastic or aggregated colloidal particles, entrapped in the mesh of filaments rising above the sheath, form a sediment in the shape of the colony. The accumulation of this sediment is mechanical; it is not due to the algal metabolism (Black, 1933a).

The specific characters of a blue-green alga, according to the classification of Recent forms, are the shape of the filament and the nature of the cells composing it; the shape of a colony may be duplicated at random by many different species. If, then, we have only the shape of the colony preserved as a fossil, we cannot, with a clear conscience, use a Linnean nomenclature for it. Likewise, it is by no means demonstrable that the characteristic patterns of lamination known by the "generic" names of *Collenia*, *Cryptozoon*, etc., are the product of any single genus of organism. Modern associations of blue-green algae, such as the sheets of *Phormidium* carpeting the bottoms of certain Antarctic lakes, are complex communities including many epiphytes (Fritsch, 1939). Blue-green algae covering lake bottoms on Southampton Island, in sub-Arctic Canada, are intimately associated with diatoms (Leechman, in Kindle, 1935); here Leechman reported that the bottom sheet was lifted, and in many cases torn, probably by the buoyancy of bubbles of oxygen produced by photosynthesis. If, in the ancient lakes in which the stromatolites were formed, the community sheath had been strong enough to resist being torn when it was lifted by the rising bubbles, a pattern of superimposed domes would have been the result of continued deposition on its surface. In modern filtration plants where a city water supply is purified, a film of algae and associated organisms is permitted to form on the surface of the sand filter.

"In some cases, and particularly where there are many filamentous algae, the film can be rolled off like a carpet . . . . Although the oxygen produced by the plants in sunlight helps the purifying effect

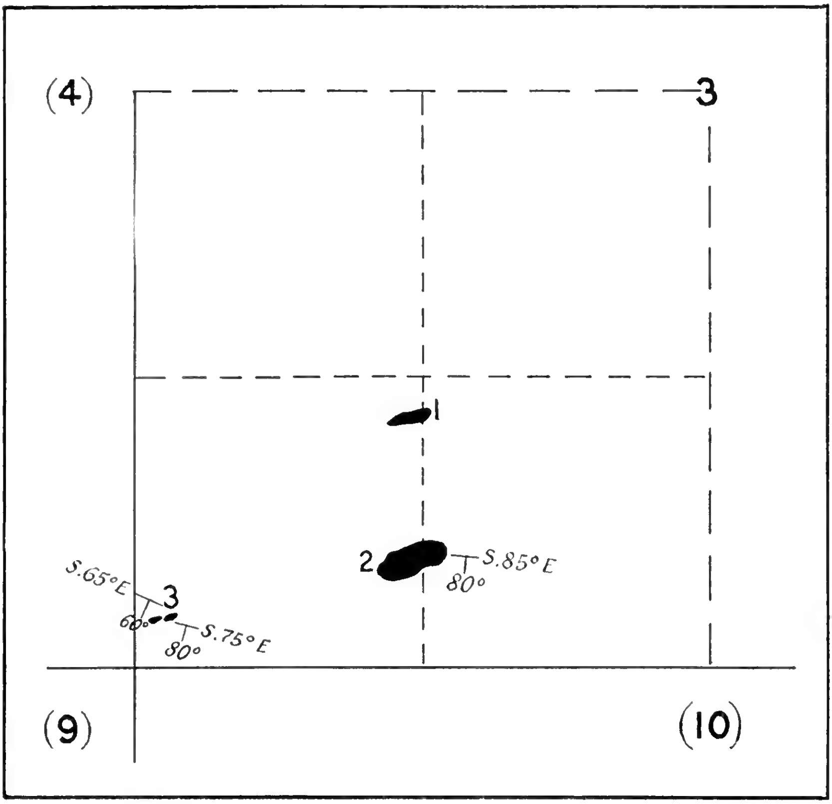

FIG. 16. Sketch-map of SW. ¼, Sec. 3, T. 42 N., R. 28 W., northern Michigan, about six miles north of Felch. Outcrops represented in black. Strike and dip determinations by Lorin Clark. An overgrown lumber trail, not indicated, winds in from the north to locality 1. Specimens from locality 1 are numbered PP2141, those from locality 2, PP2142, and those from locality 3, PP2143.

of the filter, it may temporarily spoil the film when photosynthesis is very active, by forming bubbles which burst through the 'skin' or lift it from the surface of the sand, and allow unfiltered water to get through." (Hastings, 1948, p. 23.)

Black (1933a) has observed that partial desiccation promotes the growth of algal "heads" in the modern drewite marshes of the Bahamas, and Howe (1932) has recorded structures, similar to the small algal "heads" of the Randville flora, formed as concretions by

the modern *Lithomyxa calcigena* Howe, which he described as a blue-green alga. This, however, has been determined by Dr. Francis Drouet to be an iron bacterium, rather than a blue-green alga. In view of its concentric, stromatolite-like structure, and in view of the extremely small size of some of Walcott's "algal cells," more appropriate to bacteria, it appears possible that at least some stromatolites may be of bacterial origin.

An attempt was made to observe carbonized algal cells in insoluble residues and thin sections prepared from the Randville material. The residues were obtained from blocks taken from the unweathered interior of several large pieces of the rock, the surface being then deeply etched with hydrochloric acid, the residue discarded, and the block thoroughly washed in distilled water, in order to avoid contamination by any modern water- or air-borne cells. The blocks were then dissolved in an excess of hydrochloric acid, very weak, so that too rapid effusion of gas bubbles would not rupture any cells that might be present. The residues, while containing many highly interesting clay-mineral grains, yielded no algal cells. But several of them were found to contain strands of a microscopic fungus, of the same dark pink color as the original limestone. This was regarded, with considerable enthusiasm, as evidence of the existence of fungus in the Pre-Cambrian until it became apparent that, after two weeks in the acid solution, the fungi were growing prosperously. This contamination by a modern organism of the relatively large size of the fungus has led me to doubt the antiquity of the algal cells reported by various earlier authors. Similarly, no plant cells were found in a half dozen thin sections, though certain dark spots of appropriate size resembled such cells at first glance; these, however, were grains of the very fine Carborundum powder used in the final lapping of the sections.

On the basis of my failure to duplicate the results of Walcott and others, I do not wish to deny categorically that algal cells have been seen, or that they may be capable of being preserved through half a billion years. But the most convincing evidence of organic origin, and perhaps of algal origin, of stromatolites, is, I think, in the structures described by Maslov (1938) in "*Conophyton cylindricus* (Grabau)" of the Pre-Cambrian (Sinian) of Siberia. In these structures, "thin, absolutely transparent tubes with the inside canal filled by . . . dark fine-grained carbonate . . . discontinue, then again run along the layer, and apparently bifurcate, having a broken appearance." The diameter of these tubes, sixty microns, is within the size range of the larger modern myxophycean filaments. Prob-

ably Maslov is correct in thinking that the tubes show an organic origin of the structures, but he is probably not justified, in view of Black's observations, mentioned above, in saying that "the tubes took part in the formation of the stromatolites, occurring within

FIG. 17. The exposure at locality 1. This is a typical outcrop in the Felch region, a small inlier surrounded by wooded drift. Camera facing north, strike of bed about east-west, top toward observer.

its layers and thus producing dark layers by means of emitting fine grains of the carbonate."

In summary, it appears that the stromatolites are indeed organically produced, perhaps by Myxophyceae, but the particular form of any stromatolite cannot certainly be said to be the product of a single species, and may not, indeed, be the product of a specific community. Certain stromatolites appear, from the literature, to be stratigraphically restricted, but others are known to range widely. "*Cryptozoon proliferum* Hall," for example, is restricted over a rather wide geographic range to the Ozarkian, and deserves, on purely pragmatic grounds, a name, though the use of a Linnean name seems

unsuitable. "*Collenia kona* Twenhofel," on the other hand, described in the first instance from the Kona dolomite near Marquette, Michigan (a horizon probably equivalent to the Randville), has been found

FIG. 18. A piece of Randville dolomite, sawed at a low angle to the bedding and etched to bring out the sections of several collenia-like heads. The straight lines are saw-cuts. Specimen PP2141; ×0.5.

by Maslov (1937) in Cambrian and questionably Silurian beds of Siberia, as have some of Walcott's "species" described originally from the Pre-Cambrian of North America. While great stratigraphic

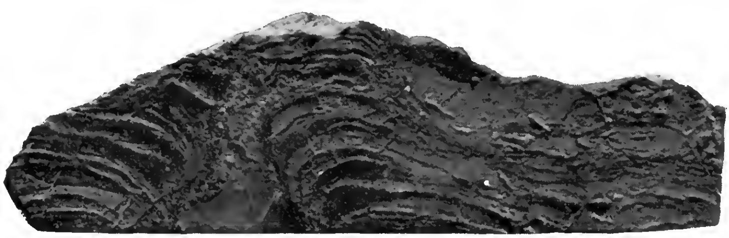

FIG. 19. Etched surface perpendicular to that shown in figure 18, on the saw-cut near the upper edge of that specimen. As oriented in the field, the top of this piece was to the south. Specimen PP2141; ×0.7.

range does not, of course, invalidate a species, it is quite in accord with the postulate that stromatolites are of ecologic rather than of genetic origin.

According to P. Vasconcelos (1949), Jamotte in 1941 used the stromatolites of certain beds in the Pre-Cambrian of Africa to con-

firm lithologic correlations. Jamotte's paper is not available to me, but it seems not unlikely, from the description of the occurrences in Angola given by Vasconcelos, that the habitat of the stromatolite-producing organisms, rather than any inherent growth-pattern, controls the megascopic character of the deposit.

THE STROMATOLITE BEDS NEAR FELCH

The Randville dolomite of Smyth (1899, p. 110, sqq.), rather scantily exposed north of Felch in gaps in the drift cover (fig. 17),

FIG. 20. Deeply etched pieces of "biscuit" stromatolites. Note approximately parallel laminae of carbonate grains of various sizes, above and parallel to the silica. Specimen PP2143; ×0.9.

is a reddish or pinkish rock, now about vertical. In the stromatolite horizons, at least, it is soluble in cold dilute hydrochloric acid, and is therefore a limestone rather than a dolomite. The stromatolites weather in relief, partly because of the silica that follows, though imperfectly, the laminar structure, and partly because of differences in coarseness of the various limestone laminae. Some of the more completely siliceous structures indicate the amount of weathering since the Pleistocene, for the white silica, preserving the smooth polished surface imparted to it by the last glaciation, stands in places an inch in relief above the pink limestone.

The stromatolites of the Randville are of four basic types, occurring with such variation and intergradation as to make it pointless, aside from the biological considerations mentioned above, to give

them formal names. Some are parallel to the bedding (the weedia[1] type) and only slightly irregular; others are "heads" of rather irregular shape (the collenia type; see figs. 18, 19); others are more

FIG. 21. A cryptozoon form of stromatolite, naturally weathered, perpendicular to the bedding. Specimen PP2141; ×0.9.

regular cylindrical heads, often of greater diameter above than below (the cryptozoon type; see fig. 21); and others are isolated "biscuits" (see fig. 20).

In the area examined, the nearly vertical beds strike about east-west, and the tops, or convex surfaces, of the stromatolite structures are turned to the south. Professor Pettijohn, the first man to find

[1] The use of "generic" names without capitalization and italicizing is recommended by Cloud (1942) to avoid the implication of a biological nomenclature.

the stromatolites in this vicinity, pointed out that the convexity indicates that the original tops of the beds are now oriented toward the south. This is a pertinent observation, based on the fact that

FIG. 22. Part of the outcrop at locality 1. Stromatolites, weathered in relief, appear as rings and circles on the bedding surface, facing the observer. The specimen in figure 21 is on the top surface of the exposure, above the head of the hammer. Lichens growing on the rock follow the etched laminae and emphasize the stromatolite structure.

all stromatolites the world over are convex upward with respect to the bedding. In the Felch area, the scarcity of outcrops and the numerous strike fault contacts leave the stromatolites as the only field indicators of the tops of the beds, a fact highly important in elucidating the structural history of the region.

FIG. 23. Part of the exposure at Lake Antoine, near Iron Mountain. Where exposed in the vertical joint, the stromatolite sections are relatively undeformed, but those visible on the horizontal surface show an asymmetry induced by a force-couple acting in the directions of the arrows sketched on the top of the outcrop.

The weedia stromatolites, thin laminae parallel to the bedding and about 25 to the inch, seem to offer no clue to the original tops of the beds. Except for the typical development of "headed" stromatolites in the beds above and below, these laminae would be taken for evidence of a simple, inorganic alternation of deposition. Their composition and spacing are the same as in the arched laminae of the collenia and cryptozoon structures, and they were probably formed by the mat of algae and associates carpeting the bottom of the Randville lake or sea. Such mats on modern bottoms are dis-

FIG. 24. Another part of the outcrop shown in figure 23, eroded at an angle to the plane of greatest distortion. Asymmetric stromatolites are seen to the left in the figure, and inclined joints, induced by the shear, to the right, where there are stromatolites of the weedia type.

cussed by Black (1933b) and Leechman (in Kindle, 1935), and, in ancient sediments, by Young (1935).

In certain layers of the limestone, the laminae are locally arched over a dome-shaped core, producing "heads" measuring from an inch to a foot or more in diameter. Weathered cross-sections, parallel to the bedding, form conspicuous rings of thin, concentric, raised lines, further emphasized by the lichens growing more prosperously on some of the lines than on others (see fig. 22). The center of the ring often appears to lack the concentric structure, but this is probably due to some sort of alteration, as longitudinal sections,

across the bedding, show continuous superposed arched laminae through the whole depth of the "head." Collenia and cryptozoon types and intermediate forms occur together, suggesting a rather complex ecology on the floor of the Huronian lake. Of all the kinds

FIG. 25. The white cornucopia-shaped object by the point of the hammer is composed of quartz and stands in high relief above the weathered limestone. It probably represents an organism. Specimen PP2143.

collected, the "biscuit" type of stromatolite (fig. 20) seems to offer the richest field for speculation. Unfortunately, most of this type were so firmly embedded that they could not be collected during the first field visit, so that this discussion is based on only three partial specimens. As with the other types, it is the outlining of the form with concentric layers of different composition, including silica, that exposes the shape on weathered surfaces. The question of whether the silica is entirely post-diagenetic, or whether it may be in part penecontemporaneous with the formation of the structure, is still unresolved. Examination of thin sections reveals a rather complex history of alternate replacement of silica by carbonate,

of carbonate by silica, and of dolomitization and perhaps dedolomitization. The silica in the biscuits follows the laminae more uniformly than in the other types of stromatolite, and this may, in itself, offer some evidence as to their origin, although no hypothesis is suggested

FIG. 26. Silica standing in high relief between two stromatolite heads. Picture nearly vertical, the top to the south. Left *in situ;* locality 3.

at present. The silica outlines a discoidal body a few inches in diameter, hollow, with both top and bottom curved upward. Adhering to the under side of both top and bottom surfaces are irregular round apophyses or pockets of silica. The outer surface of the biscuit's top is quite smooth, while the bottom, thanks to the adhering pockets, is irregular. The general form recalls certain Recent blue-green algal structures described by Mawson (1929) from "Biscuit Flat" in South Australia. These are of solid or porous limestone within, and are not silicic, but bear a strong resemblance to the Randville biscuits. Mawson states that the tops of the modern biscuits are smooth, and the bottoms irregular, "of an etched ap-

pearance." As collected, the relation of the Randville biscuits to the bedding was not apparent; they were taken from an exposure where the rock may or may not have been in place (locality 3, fig. 16). If the analogy with the South Australian structures and with other Randville stromatolites can be maintained, the convex surface of the biscuits must indicate the direction of the top of the bed. This is a matter for further field observation.

In the few exposures of the Randville formation, the stromatolite horizons cannot be traced for more than a few yards, so that their number and mutual relations are not yet determined. It appears, however, that the stromatolites in at least one part of the formation occupy a stratigraphically vertical extent of some fifty feet, in which the weedia type far outnumbers the others. Within this succession of strata are occasional beds of the collenia type. The heads arise either gradually, by an increasing arching of the laminae, or abruptly, as the laminae curve over a structureless core. Above the collenia band, the transition to weedia is either gradual or abrupt. The biscuits were found in a small, isolated outcrop that may be actually a large erratic block, though its strike conforms to that of the outcrops of bedrock.

In a fine-grained, gray, micaceous limestone of the Randville formation, beautifully exposed in an abandoned road-metal quarry at the east end of Lake Antoine, east of Iron Mountain, Michigan, are many beds of a cryptozoon structure interbedded with the weedia type (see figs. 23, 24). This is an unusually fine locality for observing the bearing of stromatolites on structural geology. I understand that we owe its preservation to the action of Mr. Frank Pardee, Michigan State Assessor of Mines, who persuaded the road-builders to leave the outcrop as they had exposed it, when he saw its geological value.

Here, also, the beds are nearly vertical, with an approximately east-west strike. The cryptozoon structures indicate, by their convexity, that the tops of these beds too are to the south. Their distortion indicates the operation of a force-couple that has produced a shear. No stromatolites presently known as "species" are characterized by an asymmetry of form in a uniform direction throughout the entire community, but it is not inconceivable that such an appearance might be caused by the action of currents. The axes of the Lake Antoine stromatolites are all tilted at the same angle to the east in each of several successive beds separated by weedia bands. It is unlikely that currents would operate thus uniformly

on several repeated occasions. Furthermore, there is an abundance of physical evidence of the operation of a force-couple to produce this asymmetry. En échelon tears, small thrusts, drag-folds, and gash veins all point to a relative motion of the lower (now northern) beds to the east and the higher (now southern) beds to the west. As seen in figure 23 (camera facing east), the couple acted in directions that can be represented by arrows on the present ground surface, gliding having occurred along the bedding planes.

In exposures not yet found, where the physical evidences may be obscured, the asymmetry of stromatolites can probably be regarded as a criterion of the existence and the direction of a shearing force. Current-controlled destruction of symmetry of stromatolites is an alternative hypothesis, but where the axes of the heads all present the same angle to the bedding, and where this is repeated in successive beds, dynamic forces alone can provide a satisfactory explanation of the asymmetry.

SUMMARY

Stromatolites are presumably formed by deposition of carbonate sediment upon and around primitive plant colonies, probably chiefly of blue-green algae (Myxophyceae), and they preserve the gross morphology of the colony. They are probably of ecotypic rather than of genotypic origin, and hence should not be given Linnean names. The stromatolites occurring in several exposures of Lower Huronian calcareous rocks in northern Michigan may be used to aid in the structural interpretation of the region, for they show the original tops of the beds, and show the direction of rotational stresses accompanying diastrophism.

REFERENCES

Black, Maurice

1933a. The algal sediments of Andros Island, Bahamas. Phil. Trans. Roy. Soc. Lond., Ser. B, **222**, pp. 165–192.

1933b. The precipitation of calcium carbonate on the Great Bahama Bank. Geol. Mag., **70**, pp. 455–466.

Clements, J. M. and Smyth, H. L.

1899. The Crystal Falls iron-bearing district of Michigan. 19th Ann. Rept., U. S. Geol. Surv., pt. 3, pp. 110–114.

Cloud, Preston E.

1942. Notes on stromatolites. Amer. Jour. Sci., **240**, pp. 363–379.

Fritsch, F. E.

1939. Algae. Encyclopaedia Britannica, 14th ed.

GRUNER, J. W.

1923. Algae, believed to be Archean. Jour. Geol., **31**, pp. 146–148.

HASTINGS, ANNA B.

1948. Biology of water supply. British Museum (Natural History), Economic Series, No. 7a.

HOWE, M. A.

1932. The geologic importance of the lime-secreting algae, with a description of a new travertine-forming organism. Prof. Paper No. **170**, U. S. Geol. Surv., pp. 57–66.

KALKOWSKY, ERNST

1908. Oolith u. Stromatolith im norddeutschen Buntsandstein. Zeitschr. d. Deutsch. geol. Ges., **60**, pp. 68–125.

KINDLE, E. M.

1935. A note on lime-separating algae from subarctic Canada. Geol. Mag., **72**, pp. 519–521.

MASLOV, V. P.

1937. On the Paleozoic rock-building algae of E. Siberia. Problems of Paleontology (U. of Moscow), **2–3**, pp. 314–325.

1938. On the nature of the stromatolite *Conophyton*. Ibid., **4**, pp. 329–332.

MAWSON, [*Sir*] DOUGLAS

1929. Some South Australian algal limestones in process of formation. Quart. Jour. Geol. Soc. (London), **85**, pp. 613–623.

MOORE, E. S.

1918. The Iron Formation on Belcher Islands, Hudson Bay. Jour. Geol., **26**, pp. 420–429.

SCHWELLNUS, C. M. and LE ROEX, H. D.

1945. Columnar, conical, and other growths in the dolomites of the Otavi system, S. W. A. Trans. Geol. Soc. South Africa, **47**, pp. 93–106.

SMYTH, H. L. See CLEMENTS, J. M. and SMYTH, H. L.

VASCONCELOS, P.

1949. On the occurrence of algal remains in the ancient rocks of Angola. Amer. Mid. Nat., **41**, pp. 695–705.

WALCOTT, C. D.

1914. Pre-Cambrian Algonkian algal flora. Smiths. Misc. Coll., **64**, No. 2, pp. 77–156.

WIELAND, G. R.

1914. Further notes on Ozarkian seaweeds and oölites. Bull. Amer. Mus. Nat. Hist., **33**, pp. 237–260.

YOUNG, R. B.

1935. A comparison of certain stromatolitic rocks in the dolomite series of South Africa with modern algal sediments in the Bahamas. Trans. Geol. Soc. South Africa, **37**, pp. 153–162.